

BIONOMICS OF THE CONE SPITTLEBUG, *APHROPHORA CANADENSIS* (HOMOPTERA: CERCOPIDAE) ON MUGO PINE IN IDAHO

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ABSTRACT.—The spittlebug, *Aphrophora canadensis* Walley (Homoptera: Cercopidae), was discovered at Moscow, Idaho, in 1979 infesting *Pinus mugo* Turra, an exotic ornamental pine. Masses of spittle, densely populated with nymphs, have continued to be abundant since then. The nymphs congregated and fed mainly on cones and did not cause visible reddening of foliage that is typical of other pine-infesting spittlebugs. Immature stages and behavior are described for the first time and are compared to other nearctic pine-infesting species. Beginning in mid-August, eggs were laid under fascicle sheaths at the bases of needles, where they overwintered. Nymphs appeared in late April and began transforming to adults in mid-July. Mating occurred from early August to late September. Adults lingered in diminishing numbers until mid-October.

In 1979, profuse masses of white spittle (Fig. 1A) of *Aphrophora canadensis* Walley appeared on 20-year-old mugo pine (*Pinus mugo* Turra) at Moscow, Idaho. We were curious about the sudden abundance of the spittle and the propensity of nymphs to congregate and feed on cones (Fig. 1B) although no cercopid is listed among North American cone and seed insects by Hedlin et al. (1980). The host is a European pine (Critchfield and Little 1966) widely grown as an ornamental in temperate North America.

A. canadensis was originally described from Victoria B.C. by Walley (1928). Doering (1941) further described the adult stage while revising the genus. Kelson (1964) observed a closely related, undescribed species³ on Monterey pine (*Pinus radiata* D. Don) and knobcone pine (*Pinus attenuata* Lemmon) in California.

Other pine-infesting *Aphrophora* species in North America include the Saratoga spittlebug, *A. saratogensis* (Fitch) (Ewan 1961, Wilson 1978); the pine spittlebug, *A. cribrata* (Walker) (= *parallela* Say of Speers 1941) (Hamilton 1982); and *A. permutata* Uhler (Kelson 1964). The former two species are eastern; *permutata* occurs in the west. The adults of *saratogensis* and *permutata* feed on coniferous hosts, laying their eggs under bud

and bark scales; the nymphs develop on understory herbaceous vegetation. All life stages of *cribrata* and *canadensis* feed exclusively on coniferous hosts.

The host plants and oviposition site of *canadensis* are reported here for the first time. Other new information involves locality records, description of immature stages, seasonal history, and behavior.

METHODS

The study area was primarily on the grounds of the Forestry Sciences Laboratory, Moscow, Idaho, at 790 m elevation. Spittlebugs were observed annually from 1979 through 1982 on mugo pine outside our insectary. Other colonies were observed and collected on 18-year-old lodgepole pine (*P. contorta* Dougl.) and ponderosa pine (*P. ponderosa* Lawson) at a residence 6 km from the laboratory. *Aphrophora canadensis* spittle masses and nymphs were observed fortuitously on older lodgepole pine at McCall, Idaho (ca 1600 m elevation), and younger lodgepole pine 27 km north of Sandpoint, Idaho (ca 750 m elevation). We also noted an infestation on mugo pine in Pullman, Washington, 16 km west of our primary study site.

During 1981, the location of eggs, nymphs, and adults on host trees, and their behavior,

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³Reported by Kelson to be *A. canadensis*, but determined to be new by Dr. K. C. A. Hamilton, pers. comm., 1 March 1982.

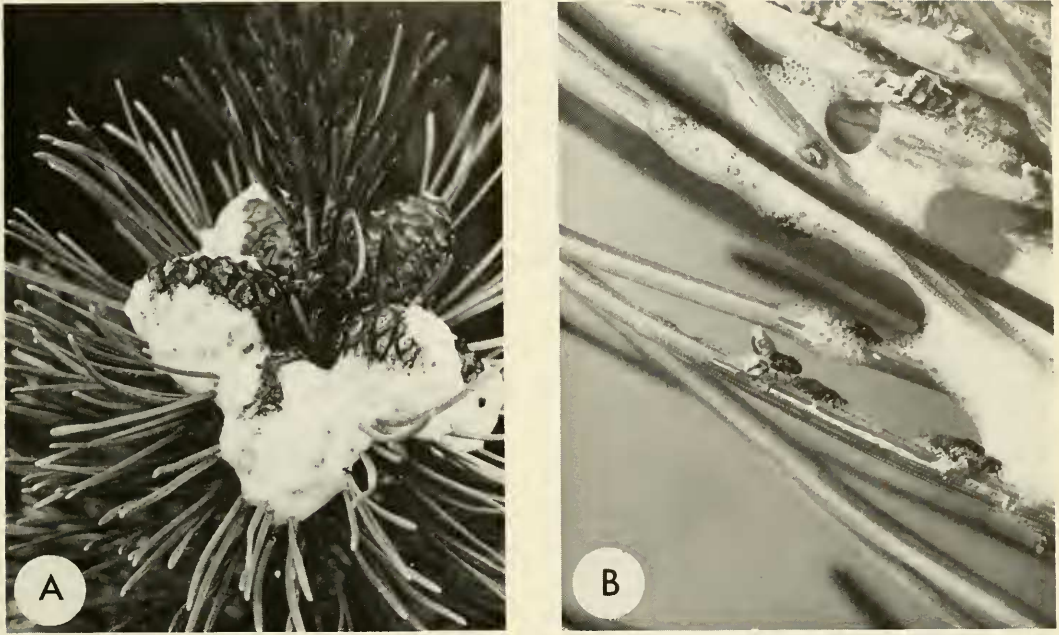


Fig. 1. Nymphs commonly formed spittle masses on cones (A), but young nymphs sometimes infested needles (B), particularly on branches that lacked cones.

were observed intensively outdoors under natural conditions. Eggs were collected and incubated in the laboratory on 18 February. Other eggs were observed on host trees weekly until hatching began 30 April; thereafter, approximately 100 nymphs were collected weekly until adults appeared 14 July. Nymphs were preserved in 70% alcohol. The five nymphal stadia were described and their proportional abundance tabulated by collection date. Approximately 50 adults of each sex were preserved for study and identification. Because the genitalia tended to distort upon drying, about one-half of the collected adults were stored in alcohol until examined.

DAMAGE

Four generations of *canadensis* had little effect on the appearance of their mugo pine hosts except for the masses of white spittle that were present from May to mid-July. Foliage was retained normally. Absent was the severe reddening of foliage as reported for other conifers in the literature previously cited on *saratogensis* and *cribrata*.

Injury by some spittlebugs has been associated with fungus infection. On red pine

(*Pinus resinosa* Ait.), *saratogensis* damage has led to infection by burn blight fungus (*Nectria cucurbitula* Tode ex Fr.) (Hepting 1971). Damage to Scotch pine (*Pinus sylvestris* L.) by *cribrata* has been worsened by infection with pine twig blight (*Diplodia pinea* (Desm.) Kickx.) (= *Sphaeropsis ellisii* Sacc.) (Speers 1941). Our microscopic examination of mugo pine needles disclosed circular yellowish or brownish areas on the basal portion of needles where nymphs had fed, but the injured areas were well defined and did not enlarge, coalesce, or kill needles. The propensity for *canadensis* nymphs to infest cones undoubtedly limited the amount of needle damage.

LIFE STAGES

Egg

The egg (Fig. 2) is pearl white initially, becoming turquoise with maturity. It is elongated teardrop shaped, average length 1.74 mm, and width 0.56 mm, and is more acutely tapered at the emergence end, which has a black, scablike subapical plate approximately one-fifth the egg's length. No mention was made of this plate for the pine spittlebug (Speers 1941) or the Saratoga spittlebug



Fig. 2. Eggs were deposited under needle fascicle sheaths. Scablike apical plate is visible on egg at left (arrow).

(Ewan 1961). The plate is narrow and lanceolate. The smooth chorion is rubbery and durable. It overlays an inner, darker covering, from which it can be easily separated by rupturing the chorion with pointed forceps. The inner covering of the egg is finely pebbled in appearance. An orangish yolk is visible in overwintered eggs.

Nymph

There are five nymphal instars, the first four of which appear to the unaided eye nearly identical except for size. Instar 5 (Fig. 3) exhibits a light and dark color phase, the lighter of which is more common and similar to the previous instars. The body length ranges from about 1.7 mm for the 1st instar to 6 to 8 mm for the 5th. The head widths for each instar are shown in Table 1.

Kelson (1964) described the head and thorax of instars I to IV of his undescribed spe-



Fig. 3. Instar 5 nymph.

cies as "shiny black." In the first four instars of our specimens, the shieldlike head, thoracic nota, and appendages are uniformly medium to dark brown with amber or ivory-colored articulations and with a thin median amber line running dorsally over the frons and down the thorax. The sternum is lighter in color, more golden brown and ivory. The eyes are red. The frons, inflated like a riot-officer's helmet, appears especially dark and shining in the first two instars. In the later instars, the golden horizontal striations on the frons appear increasingly gridlike. The squared-off lateral edge of the dark pronotum is a contrasting ivory color in all but the first instar.

The abdomen shows the greatest developmental variation, differences in which will be described by instar hereafter. The abdomen of the first four instars is tangerine-yellow except for the caudal segments discussed hereafter, and has a localized bright rasp-

berry red blush along the sides of the widest segments. The median line of the thorax continues as a yellow-stained furrow to abdominal segment 9. The laterotergal margin of segments 3 to 9 is folded under along the cream-colored sternum and equipped, especially in the older instars, with opposing, sometimes overlapping plates that open and shut against one another ventrally to form spit-bubbles. The venter of the third segment, like that of the pine spittlebug (Speers 1941), bears a prominent nipplelike process which, we believe, acts as a gasket or air-seal when the tergal plates draw shut. The plates of this segment truncate basally to fit against the correspondingly modified fleshy shelf on each side of the nipple. Protruding beyond segment 9 is a small, truncate anal segment ringed apically by two pairs of brown ridges and possessing a brown ventral plate. This segment is similar in all instars.

INSTAR I.—The head and pronotum are entirely dark brown. Abdominal tergites 3 to 6 are stained raspberry red laterally; segments 7 to 8 are orangish yellow dorsally. The tube-shaped segment 9 is divided lateroventrally into two sclerotized dark brown tergal lobes resembling bomb-bay doors. The tergal lobes of segments 3 to 8 are unpigmented, with thin crescent-shaped borders. The shallow, concave sternite 9 bears a brown, flat trapezoidal plate, from which the genitalic structures will arise.

INSTAR II.—Golden brown gridlike striations are faintly visible on the frons. Pronotum in this and the following instars have cream-colored lateral edges. Raspberry blush is present on abdominal segments 3 to 6. The pink blush mentioned by Kelson (1964) is reduced to segments 4 to 6. Segments 7 and 8 are ivory colored except where stained yellow by the dorso-median furrow. A smoky brown patch on the side of segment 8 is

faintly evident. The dark tergal sclerites of segment 9 meet dorsally in this instar to form an irregular saw-toothed ring with an ivory edge. In addition, the laterotergal lobes of segments 8 and 7 (and sometimes 6) are variably tanned smoky brown, especially near the anterior corner of each lobe. The inner surface of the caudal lobes is likewise sclerotized, doubly reinforcing the "doors" of the bubble-chamber.

The pregenital plate of segment 9 is shallowly cloven medially, and sometimes a light brown, heart-shaped process may be evident at its base.

INSTAR III.—Head is medium brown with golden brown joints and striations. Wing pads are faintly evident, but not at all expanded posteriorly. Raspberry suffusion is reduced to abdominal segments 4 to 6; tergites 7 and 8 are ivory, with smoky patches developing laterally and ventrally, especially on 8. Tergite 9 is darkly sclerotized and subcylindrical in shape. Pleural lobes of segments 3 to 9 are edged with light brown; scooplike borders are still crescent shaped, though wider than in previous instars.

Two similar pairs of genitalic buds have emerged from the pregenital structures between segments 8 and 9. We still could not differentiate between sexes at this stage.

INSTAR IV.—Golden-brown frons is decidedly lighter than the dark brown vertex and thoracic tergites. Without magnification, the latter appear blackish, especially in living specimens. Rudimentary wing pads are present, appearing as dark notal extensions with cream undersides.

Abdominal coloration is as in the previous instar. Segment 9 is completely sclerotized dorsally and laterally, with in-rolled edges shutting together ventrally. Segments 7 and 8 are now darkly patched along the sides just above the pleural margin and to the rear of the raspberry blush on the middle segments. The borders of all abdominal pleural lobes are stained smoky brown and have grown into large, flexible, incisorlike plates resembling fish scales.

Though still rudimentary, the genitalia of either sex can be differentiated in this instar. In the female, the two pairs of genitalic buds have become lobelike and dissimilar. The outermost pair, which arise on segment 8, are

TABLE I. Head widths of the instars of *A. canadensis*.

Instar	No.	Head width (mm)	
		Average	Range
I	20	0.64	0.57-0.68
II	20	0.86	0.81-0.91
III	20	1.22	1.15-1.28
IV	20	1.72	1.55-1.80
V (♀)	17	2.39	2.30-2.60
(♂)	18	2.21	2.05-2.40

parallel and contiguous along their midline, resembling harem trousers; the lobes of the inner pair are broadly separated and lie off to the sides. In the male, the two pairs of phallic lobes are alike, each pair being cleft, and they lie stacked like boxer shorts, one atop the other.

INSTAR V.—About one-fifth of the individuals are melanistic. The females are larger than the males, and the dark phase of each is slightly larger in size than the light phase:

Color phase	Female	Male
	Av. (Range)	Av. (Range)
	mm	mm
Light	2.37 (2.3–2.5)	2.20 (2.1–2.3)
Dark	2.42 (2.3–2.6)	2.23 (2.05–2.4)

Ewan (1961) mentioned that instar 5 Saratoga spittlebugs darkened from tan to light brown later in the stadium. Ours remained either distinctly light or dark. Speers (1941) observed melanism only in male pine spittlebugs, but both sexes of our specimens displayed both color phases. Kelson (1964) did not mention any melanism or color dimorphism in specimens of the related, undescribed species.

The most striking color difference between these variants occurs in the abdomen, as described later. In both color phases, the head and thorax are a lighter brown than in the previous instars, especially the clypeus, which is now golden straw colored, with light brown striations. The vertex is the color of the striations and has acquired two ocelli, outlined in bright strawberry pink, like the eyes. A pair of amber patches lie between the posterior margin of the compound eyes and the ocelli.

The pronotum is uniformly medium brown and sometimes darker than the other two thoracic nota. The lateral borders vary from cream to yellow. The meso- and metanota are likewise a uniform brown, marked only with a thin median line. In contrast, Kelson (1964) described “2 white spots” on the metathorax of his undescribed species, “centered between the midline and the lateral edges.” The dark wing pads coattail down nearly as far as the third abdominal segment. The upper pair is margined ivory along the anterior rim and has, on each bud, two vague ivory submarginal blotches. The underside of

the nymph, including the wing pads, is predominantly golden-ivory, highlighted in brown.

The instar 5 abdomen is more tanned than that of the previous instars. As a result, the bright colors are less pronounced, as though seen through thick isinglass. In light phase specimens, the tergites are tan, with a faded salmon blush along the sides of segments 4 to 6. The margins of tergites 7 to 8 have patches as dark as the thorax, but the cylindrical segment 9, in contrast with that of the previous instars, is nearly as light as the rest of the abdomen. A faint yellow-stained broken median line is evident on the darker plates of the last three abdominal segments.

In dark specimens, the dorsum of the abdomen is just as dark and smoky (almost blackish) as the thorax, with a cream or light amber broken median line. The sides of tergite 3 have large pale ivory patches. The sides of tergites 4 to 6 are tinted light brown, with a pinkish undertone. The side blotches of tergites 7 and 8 have grown into dark saddles interrupted dorsally by the pale midline and laterally by an ivory border separating them from the laterotergal lobes. Tergite 9 is faded to golden brown, and is sometimes lighter than the rest of the abdomen.

Occasional intermediates between the two color phases have tawny abdominal segments transversely striped to varying degrees of darkness. Kelson (1964) described the abdomen of all the instar 5 nymphs, of the related, undescribed species, as white or nearly white, except segments 7 to 9, which were black.

The laterotergites of this instar are broad and subsquare, expanding like fins from the membranous pleuron, and flatly enclosing the entire caudal length of the sternal chamber up to the fleshy shelf and gasketlike nipple of segment 3. Flexing of the abdomen pulls these plates open and apart. The nipple, prominent in the earlier instars, is reduced to a small nodule in this instar.

The female genitalic lobes are proportionally 2X longer than in the previous instar, darker brown and more conspicuous, otherwise unchanged. The male lobes have grown, both pairs now resembling Dutchman's breeches, the legs of which spraddle wide apart. They lie on the venter of segment 9.

Those of the female extend across the sternum of both segments 8 and 9.

Adult

Our adult females average 9.18 mm long (range 8.6 to 10.0 mm); males average 8.23 mm (range 7.6 to 9.2 mm). Both are of uniform coloration, varying from chestnut tan to chestnut brown with age. The abdomen of older males is much darker than that of females—the tergites becoming blackish. Markings are otherwise identical between the sexes.

A creamy white inverted Y is discernible on the dorsum (Fig. 6D) similar to that of *cribrata*, the thin leg of which runs medially from the apex of the head down to the caudal apex of the scutellum, the wide chevron obliquely banding the hemelytra to either side. In *saratogensis*, this marking is more conspicuous, broader, and lance-shaped. Preserved or callow specimens of *canadensis* are more homogeneous brown than when alive or mature, and the Y is inconspicuous.

The frons of *canadensis* is not so bulbous and inflated as that of *cribrata*. In lateral view, the face meets the vertex at an acute angle, the apex of the head tilting upward like a pig's snout. The crown of *canadensis* is long in comparison with the thorax, and the head is wider than the thorax.

The male genitalia of *canadensis* has been diagrammed and discussed in detail by Wall-e (1928) and by Doering (1941) and will readily distinguish this from other species of *Aphrophora*.

SEASONAL HISTORY AND BEHAVIOR

Egg

Eggs were present from mid-August until mid-May. *Aphrophora canadensis* overwinters in the egg stage among the needle clusters of the current year's terminals. Like those of the Saratoga spittlebug on jack pine (*Pinus banksiana* Lamb.) (Ewan 1961), the eggs of *canadensis* are inserted separately into the fascicle sheath surrounding the base of each needle cluster, oriented parallel to the needles with the black sutured end upward. The egg is not glued or rooted in any

way but held secure by the encircling fibers of the fascicle sheath.

Frequently, more than one egg is inserted in a fascicle (Fig. 2). Four branch terminals were examined for eggs in late September 1981. Of the 300 fascicles counted, 30 had eggs, distributed as follows: 19 fascicles had 1 egg, 8 had 2, 2 had 4, and 1 fascicle had 5 eggs.

Hatching

Nymphs hatched between late April and mid-May. A typical individual required 15 minutes to hatch. The black trapdoor broke from the chorion, tilting slowly downward like a tiny drawbridge. Simultaneously, there appeared in the gap an orange bulge pressing upward like a shining balloon, pushing the lid outward as it rose. Soon two small dark eyes became evident, then the folded mouth parts and the sealed appendages, as the creature ascended by slow increments through the top of its blue shell. For 5 minutes it lay on the substrate, arching and writhing its sealed-up looking body, after which the antennae lifted free from the face. Seven minutes later, the legs unfolded. Three minutes more, and the nymph was climbing to its feet, ready to run. The shed skin was hardly noticeable; the appendages seemed simply to separate from the body as if by drying.

Feeding and Spittle Formation

Upon gaining its feet after hatching, a nymph would run out along the length of a needle, dragging its disproportionately long beak between its legs—for in newly hatched nymphs this organ extends ventrally to almost the abdomen's apex. Pausing a little below the tip of the needle on the dorsal surface, the nymph heaved its head back while rearing high on its legs and sank its colossal beak into the needle.

Nymphs cannot form spittle until they have begun feeding. While the nymph sucks, its head pulses actively. Meanwhile, a clear, viscous liquid begins to drool down the slightly elevated abdomen and over the entire insect, accumulating between its legs in the manner described for the pine spittlebug by Speers (1941). To produce bubbles, the

nymph then flexes and rears its abdomen (Fig. 1B) against the surface tension of the slime covering it, and dilates the ventral valvelike plates of segment 9. This dilation creates a V-shaped, snorklelike opening, allowing air to enter the sternal chamber.

The valves shut as the tip of the abdomen is pulled back into the liquid. Then, with a sidewise twist of the abdomen, they open again and release a large bubble. The sequence is repeated on the opposite side. This procedure takes place at a fairly rapid rate, back and forth from side to side like a mechanical shuttle, producing bubbles of similar size.

Feeding Sites

Hatchlings do not usually create much spittle, nor do they remain solitary for long. Within a few days to a week after hatching they abandon their initial feeding sites and wander about intermittently until they find another suitable feeding site.

The ripening female cones provide a large and nutritious surface and are favored as feeding sites. As many as 100 individuals may gather on one cone. If cones are absent from a branch, smaller aggregations form in the axils of needle clusters, especially on current-year terminals. Where two or three spit-makers have joined company, others will congregate on discovering the frothy oasis. This sharing doubtless has survival value by reducing the individual effort needed to maintain a large canopy of foam. Many nymphs become motionless while feeding, with their tails sticking through the froth and ventral vent passively open to the air as if to breathe.

The numbers of nymphs aggregated at a feeding site decreased as the nymphs molted and grew, due probably to crowding and subsequent migration. By instar 5, a few spittle masses contained only one or two nymphs. Younger aggregations were limited to the terminal portions of a tree while older instars, especially the 5th, were sometimes found feeding and foaming along the older, woodier (third to fifth year) portions of branches, if needles were retained there. Such nymphs fed adjacent to the base of a needle cluster, frequently in contact with it, and always ori-

ented head downward with respect to gravity. In contrast, nymphs on cones were arranged every which way, top and bottom, over the cobbled surface, wallowing in one another's spittle. Nymphs congregated on the more sheltered base and undersurface of cones only when their numbers were too small to maintain a large canopy of foam against the summer sun. More typically, the nymphs were assembled over the entire cone, collectively exuding a long white beard of spittle (Fig. 4) dripping to the branches below.

Seasonal Occurrence of Nymphal Stages

Instar 1 nymphs were present in 1981 on trees beginning the last week in April through 22 May; instar 2 nymphs were collected from 5 May through 12 June; instar 3 between 4 June and 22 June. Instar 4 specimens were present in samples between 12 June and 9 July. The instar 5 appeared by the end of June. Spittle masses diminished after mid-July, when nymphs began transforming to adults, but persisted through the first week of August.

Adult Emergence and Behavior

At the end of instar 5, the nymphs left the foam and climbed along pine needles to perch near the apex and shed their final exuviae (Fig. 5). Hanging with legs wrapped around the needle, they glued themselves in place by letting their abdomen dry against the perch. After swelling their thorax for several minutes, the midline of the dorsum split lengthwise. The pale, waxen-appearing imago emerged partway and hung from the exuviae by its abdomen, head downward and back concavely arched, the legs folded. The wings were mere buds at this time. The imago remained in this position for several minutes; then, stirring its legs restlessly, caught hold of the exuviae and drew itself forward to extract the abdomen. Still gripping the exuviae, the imago continued to hang from below, back arched, the four waxen white wings held apart and slowly unfurling (Fig. 6A). When the wings were expanded and dry, the adult stirred from its



Fig. 4. Commonly, spittle on cones was so massive as to drool drops of liquid. Caudal end of mature nymph is visible at right of center.



Fig. 5. Exuviae of instar 5 nymphs attached to pine needles.

arched posture, oriented the wings horizontally by shaking them, and folded them shut over its back. All of this required about 30 minutes, at which time the adult was still pale yellowish tan with salmon eyes and ivory wings (Fig. 6C). Mature coloration (Fig. 6D) was attained within a few hours.

Some newly transformed adults roamed freely among the plants, but most preferred the cooler, more shaded portions. Within a few days after ecdysis they began congregating along the terminals to feed, becoming especially active in the late afternoon, when the trees were shaded. As many as 12 adults were counted on the distal 8 inches of a branch.

Adults appeared to feed on the needles as well as on the woody tissues. The brush of needles surrounding the sticky apical bud of a branch was a favorite feeding site. Hoppers often arranged themselves in a ring around the bud, perching on the upper surface of the needles, one per fascicle, facing outward from the branch. Others farther down the limb perched on the needles or crouched against the bark between the fascicles, always oriented with head toward the end of the branch.

While feeding, the hoppers frequently stood motionless with the head and body tilted at an angle of about 30 degrees above the substrate, looking very alert. Positioned thus, they strongly resembled in both shape and coloration the tiny, reddish brown current-year buds. Older and browner specimens were practically invisible against the reticulated scaly surface of the branch, the thin white chevron on their wings matching the onionskinlike fibers of the surrounding fascicles.

When alarmed, the camouflaged hoppers catapulted themselves into the air with remarkable force, making a sharp, snapping sound as they sprang. Girault (1904) likewise noted that pine spittlebugs made "a sound similar to that of a steel spring when suddenly loosened."

Although adult hoppers do not manufacture spit oases, they do secrete honeydew, droplets of which are ejected periodically in rapid-fire bursts, cascading downward in a series of glistening streamers. The hoppers feed and fire droplets throughout the day and night and during copulation, similar to *cribrata* (Speers 1941).

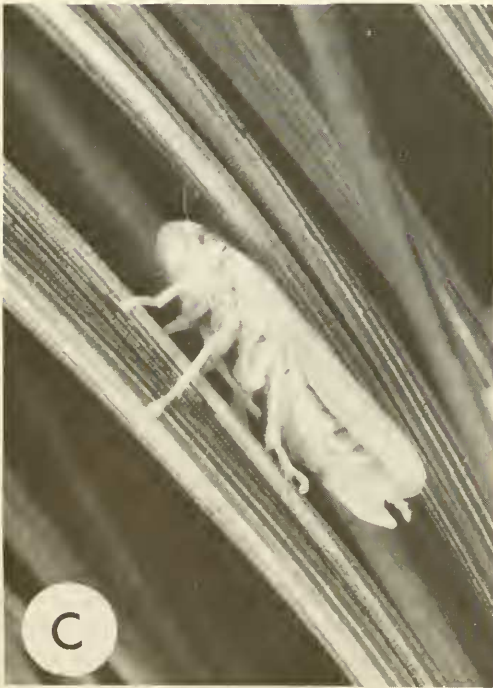


Fig. 6. A, B, C, stages during transformation to adult; D, mature adult with characteristic white chevron wing marking.

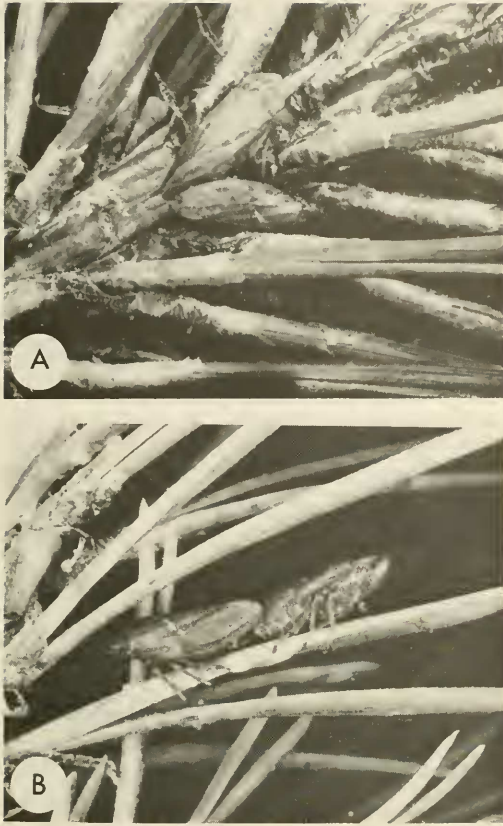


Fig. 7. Most adults assumed a V-stance (A) while mating; others lined up end-to-end (B).

Mating

Copulating pairs were first observed 3 August at 5:00 p.m. Previously, we had searched for paired hoppers only in the morning, finding none. Most couples were engaged side by side, in a V position, their heads pointed toward the end of the branch (Fig. 7A). Some partners also assumed the mating stance described for *cribrata* by Speers (1941) and Girault (1904). In this stance the pair faced away from each other (Fig. 7B), tails overlapping approximately three caudal segments, and the male partner always faced down the branch toward the stem.

The male approached the stationary female by backing tail-first into position. After making contact, copulation ensued. Sometimes they remained thus, facing opposite directions up and down the branch. But more frequently the male pivoted around on his

partner until both faced up the branch, side by side.

Copulation lasted several hours, beginning in the afternoon. The partners fed while so engaged. If a male was purposely disturbed by careful poking, he immediately disengaged. Similarly disturbed females were unable to detach from their smaller mates, and often dragged them around helplessly for several minutes.

The hoppers mated until the end of September. Adults survived several weeks of intermittent frost and were last seen 21 October.

ACKNOWLEDGMENTS

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LITERATURE CITED

- CRITCHFIELD, W. B., AND E. L. LITTLE, JR. 1966. Geographic distribution of the pines of the world. USDA For. Serv. Misc. Publ. 991, 97 pp.
- DOERING, K. C. 1941. A revision of two genera of North American Cercopidae (Homoptera). J. Kansas Entomol. Soc. 14:102-134.
- EWAN, H. G. 1961. The Saratoga spittlebug: a destructive pest in red pine plantations. USDA For. Serv. Tech. Bull. 250, 52 pp.
- GIRAULT, A. A. 1904. Miscellaneous notes on *Aphrophora parallela*. Canadian Entomol. 36:44-48.

- HAMILTON, K. G. A. 1982. Taxonomic changes in *Aphrophora* (Rhynchotha: Homoptera: Cercopidae). Canadian Entomol. 114:1185-1189.
- HEDLIN, A. F., H. O. YATES III, D. CIBRIAN TOVAR, B. H. EBEL, T. W. KOERGER, AND E. P. MERKEL. 1980. Cone and seed insects of North American conifers. Canada For. Serv.; USDA For. Serv.; Secretaría de Agricultura y Recursos Hidraulicos, Mexico. Printed in Canada. 122 pp.
- HEPTING, G. H. 1971. Diseases of forest and shade trees of the United States. USDA For. Serv. Agric. Handbook No. 3856. 658 pp.
- KELSON, W. E. 1964. The biology of *Aphrophora permutata* and some observations on *Aphrophora canadensis* attacking Monterey pine in California (Homoptera: Cercopidae). Pan-Pacific Entomol. 40(3):135-146.
- SPEERS, C. F. 1941. The pine spittlebug (*Aphrophora parallela* Say). Bull. New York State Coll. Forest. Tech. Pub. 54, Vol. 14, No. 2a. 65 pp.
- WALLEY, G. S. 1928. The genus *Aphrophora* in America north of Mexico (Cercopidae, Hemipt.). Canadian Entomol. 60:184-192.
- WILSON, L. F. 1978. Saratoga spittlebug. USDA For. Serv. For. Ins. and Dis. Leaflet 3. 4 pp.